# A new iterative cut and adaptive coordinate transform method for fast page outline detection and dewarping

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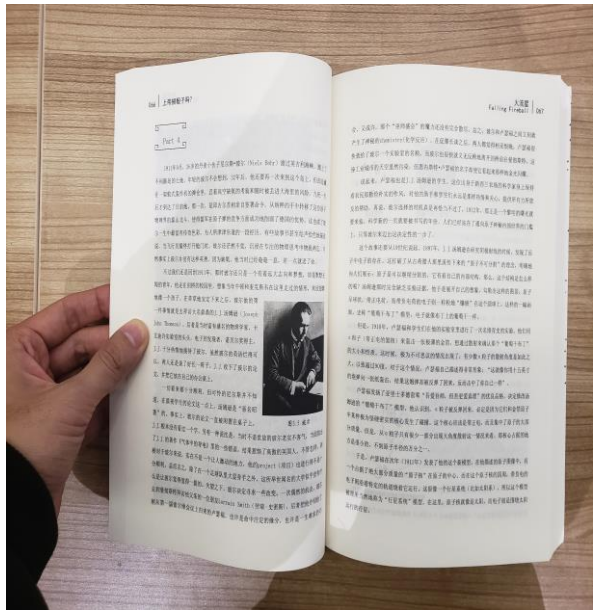
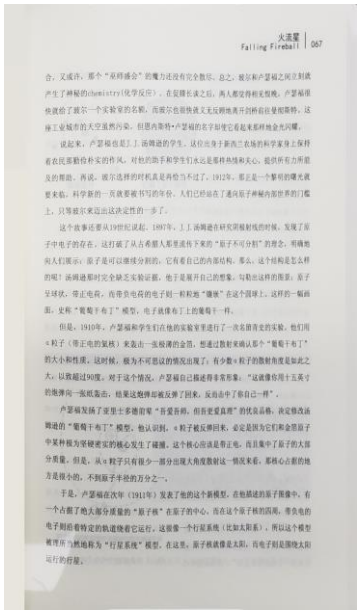
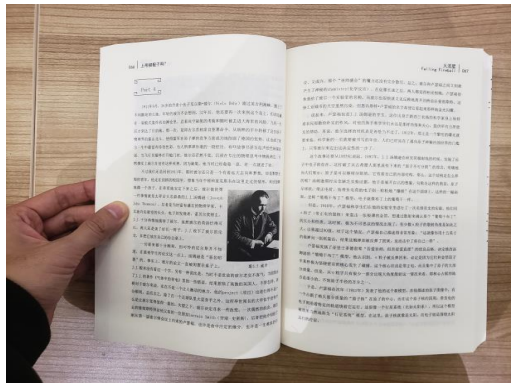
# Motivation & Design principle

- Digitize physical books to pdf
  - Detect and segment book pages
  - Dewarping and reconstruct a high-quality image to improve readability
  - Improve OCR accuracy
- Design Principle
  - Low computation consumption
  - Robust

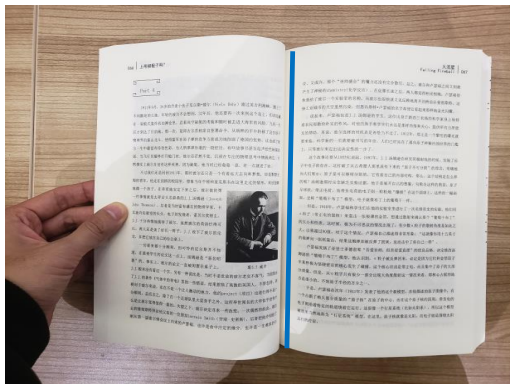




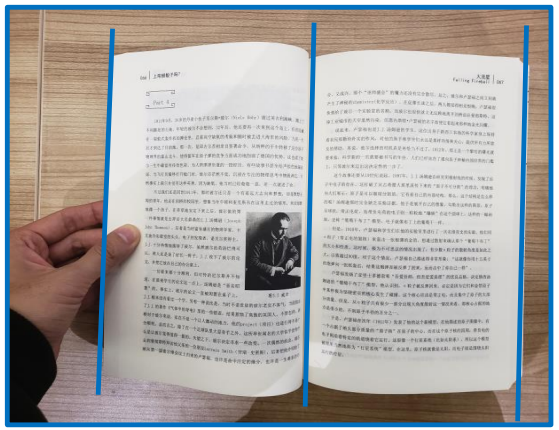
# Workflow of our system



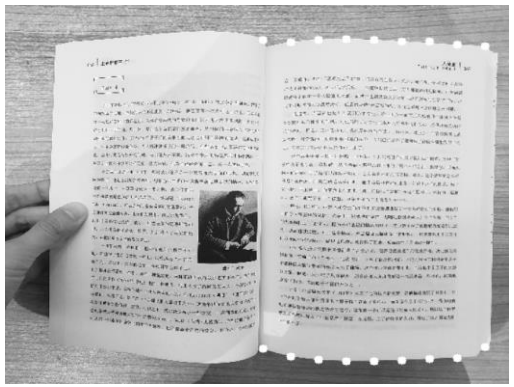
Input



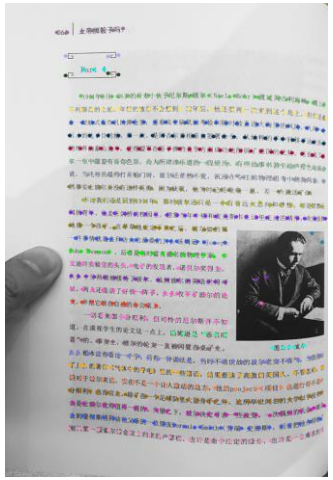
Page split



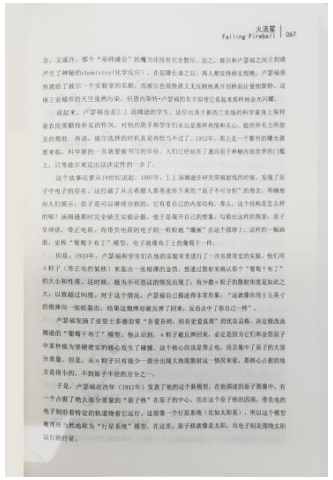
Page left-right outline



Page top-bottom outline



Text-line detection



Dewarping and finger-removing

Fig. 1.

# Page Outline Detection

# Pipeline of book outline detection

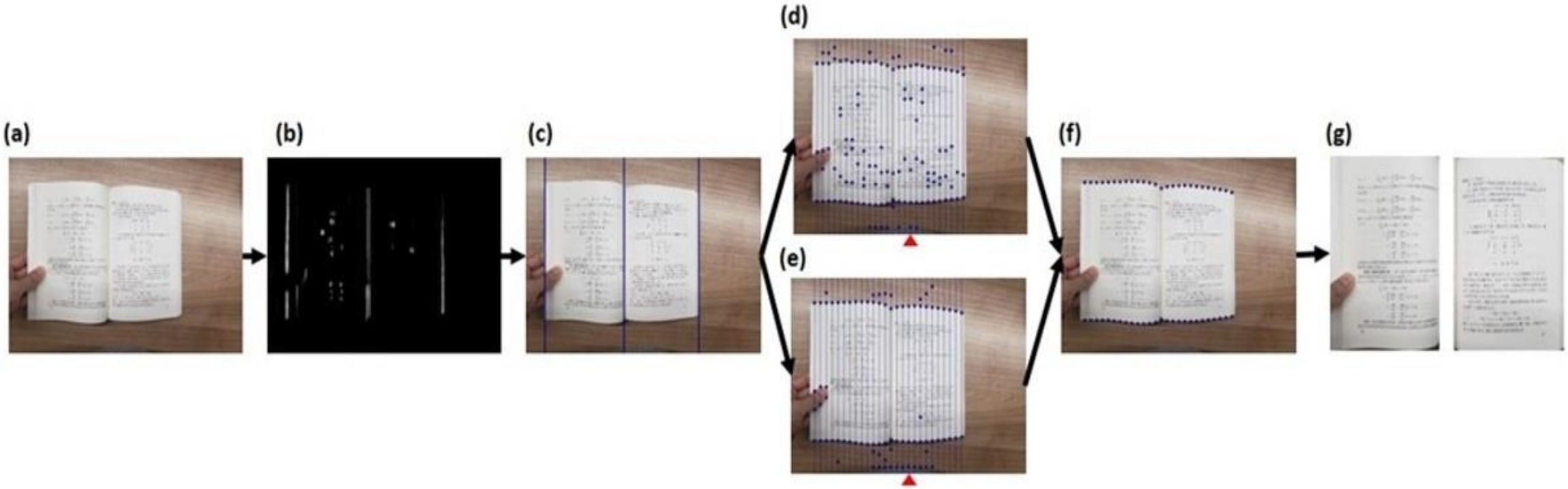
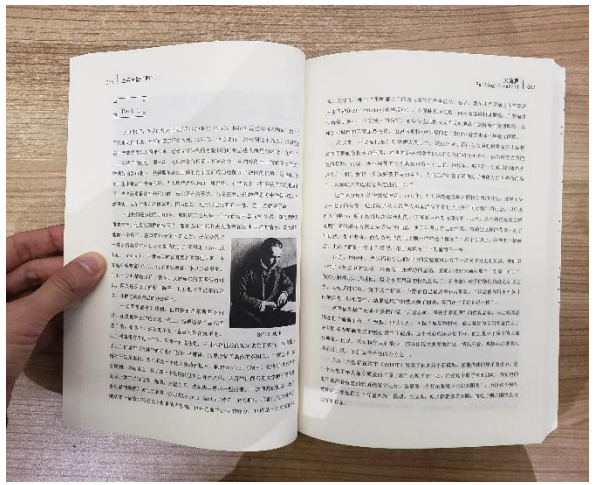
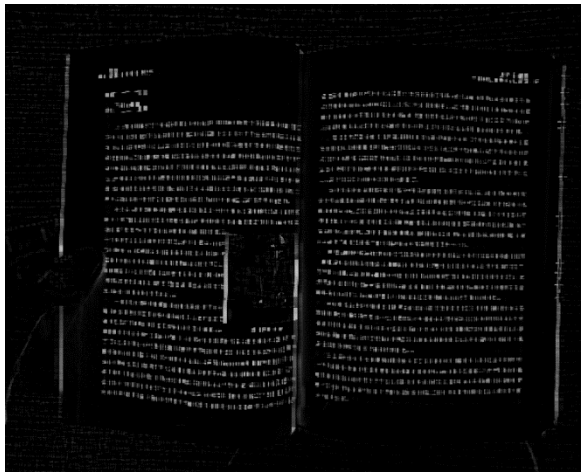



Fig. 2. (a) original image, (b) horizontal gradient map, (c) left and right boundaries detected by Hough transform, (d) and (e) calculated transition points on the brightness channel and saturation channel, respectively, (f) top and bottom outline, and (g) cropped pages using corner points.

# Left-right outline detection

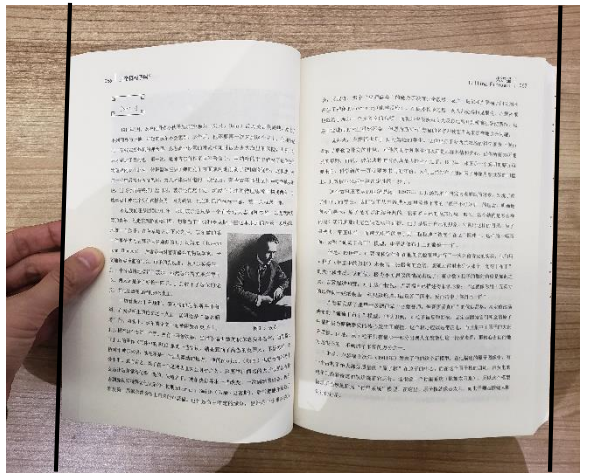


Input image



Vertical gradient map

Opening operator



Hough line detection for left/right boundary

# Top-bottom outline detection –Transition points detection

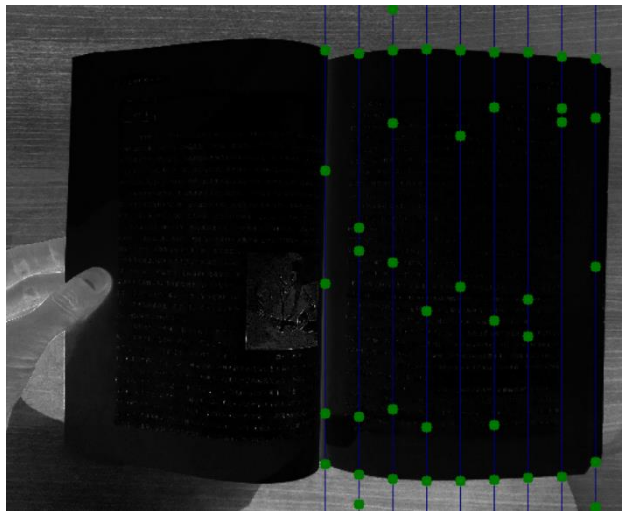


Fig. 3. Detected transition points overlaid on saturation channel

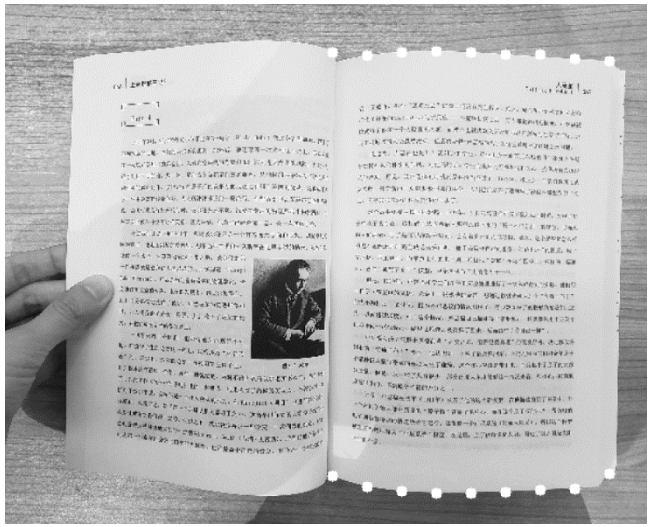


Fig. 4. Detected top/bottom boundary

- **Uniform sample column pixels (blue lines in Fig. 3).**
- **Detecting transition points on each column pixels on saturation/brightness channel ( maximize inter-class variation), respectively (points in Fig. 3).**
- **Horizontally linking transition points based on vertical distance and vertical gradient magnitude**
- **Selecting the longest link as top/bottom boundary (bright points on Fig. 4)**

# Outline detection – advantage & principle

- **Low computation consumption**
- **Robust**
  - **Robustness in a complex background**
  - **Detect curving page outline**

# Dewarping methods

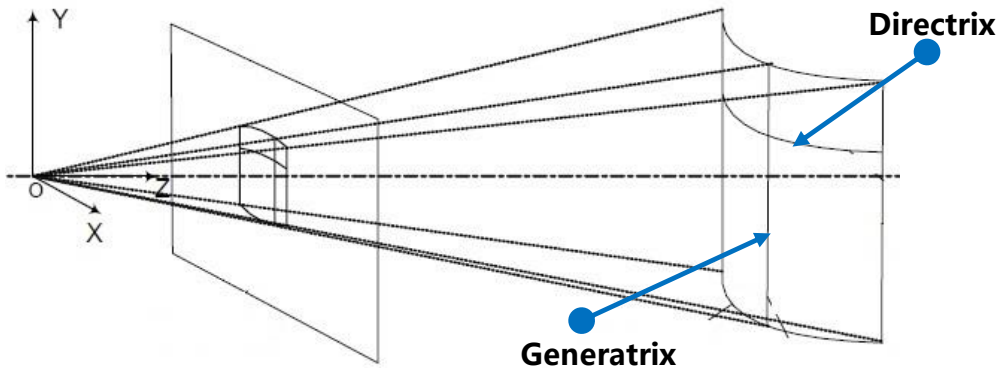
# Adaptive Dewarping method

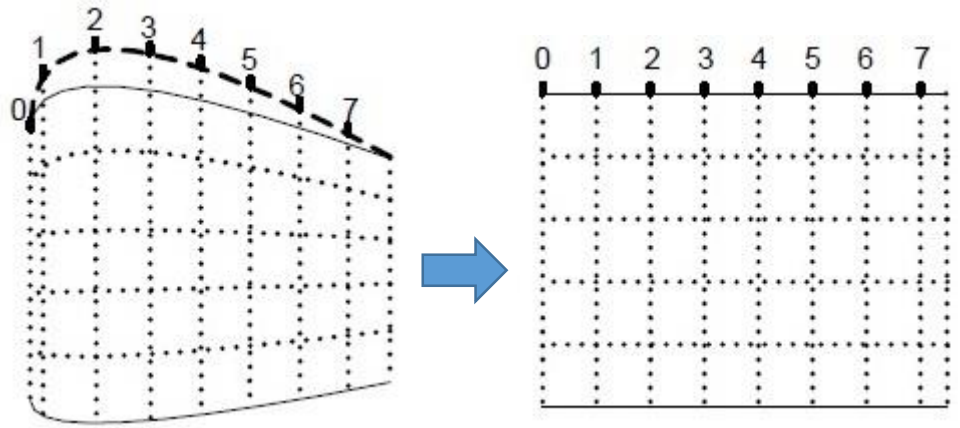
- **Hybrid method**
  - **General Coordinate Transform Model( GCTM)**
  - **Optimization-based dewarping method (ODM)**

  **Method selection based on top-bottom curve layout**

# General Coordinate Transform Model(GCTM)

- **Models the page as a cylinder surface**
- **Mapping between directrix is a linear transformation( Generatrix same)**
- **Use top/bottom text line and their scaling relationship to dewarp whole page**





Reference:

*1* H. Cao, X. Ding, and C. Liu, "Rectifying the bound document image captured by the camera: A model based approach," in Proceedings of the 2003 Seventh International Conference on Document Analysis and Recognition, 2003, pp. 71-75: IEEE.

# Optimization-based dewarping method (ODM)

- **Model the elevation of page as a polynomial**
- **Optimize the parameters**

  **By minimizing the mapping error between straight textline and warped textline.**
- **Advantage**

  **Avoid significant artificial distortion ( based on all text-lines of image)**
- **Disadvantage**

  **May fall into local minimization, leading to dewarping-effect is not obvious.**

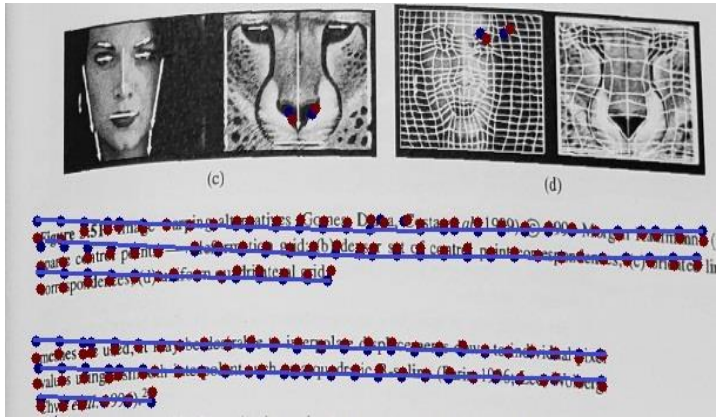



**Fig. 5. Optimization procedure makes the straight blue line on top of red curved text line.**

# ACTM Dewarping method

Switch dewarping method based on top-bottom curve layout

- **Switch logic**

  ***if( distance between the top and bottom curves > image height * alpha )***

  **Implement GCTM;**

  **else**

  **Implement ODM;**

  ***Note: alpha [0.4 ~ 0.5]***

# Dewarping Refinement

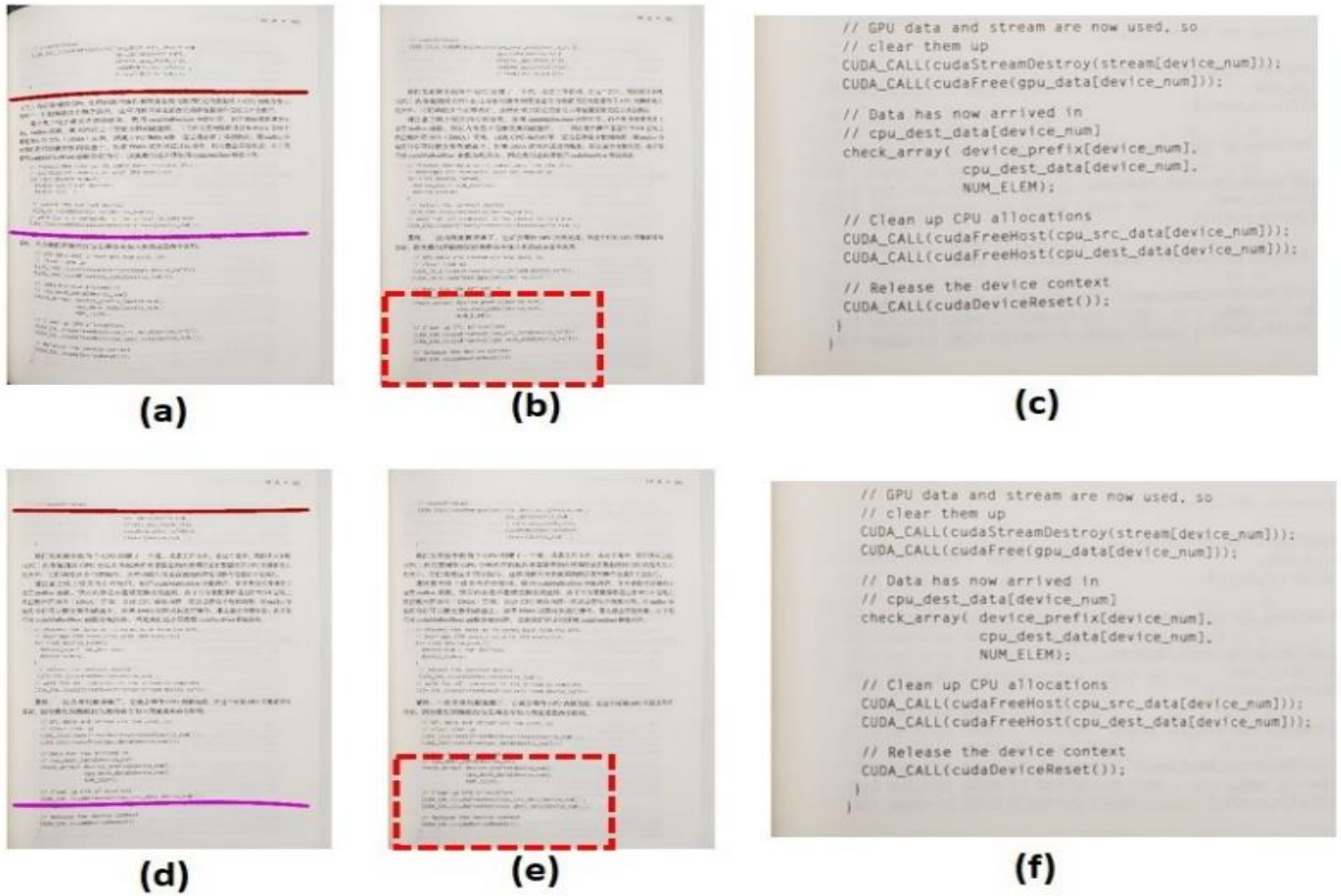
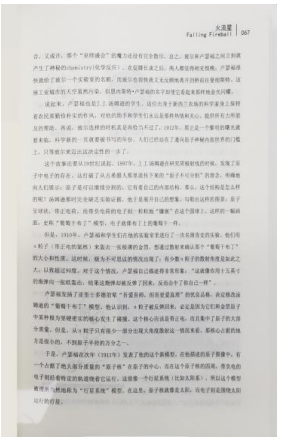


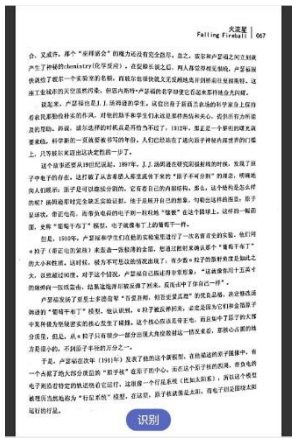

Fig. 6. Coarse-refinement dewarping procedure. The top panel shows results of the coarse dewarping procedure and the bottom panel shows results of the refinement dewarping procedure.
(a, d) detected top and bottom curves, (b, e) dewarped image, and (c, f) enlarged images of the insets in the dashed rectangle.

# Result compare (1)

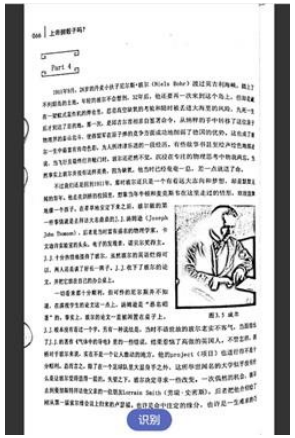
Input

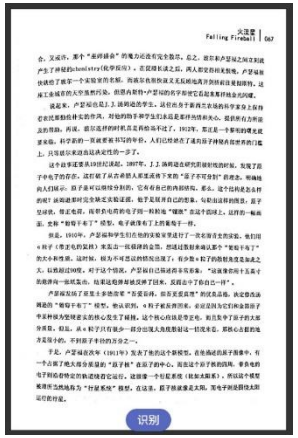


Our Result



Abbyy output(1)





Abbyy output (2)

# Result compare (2)

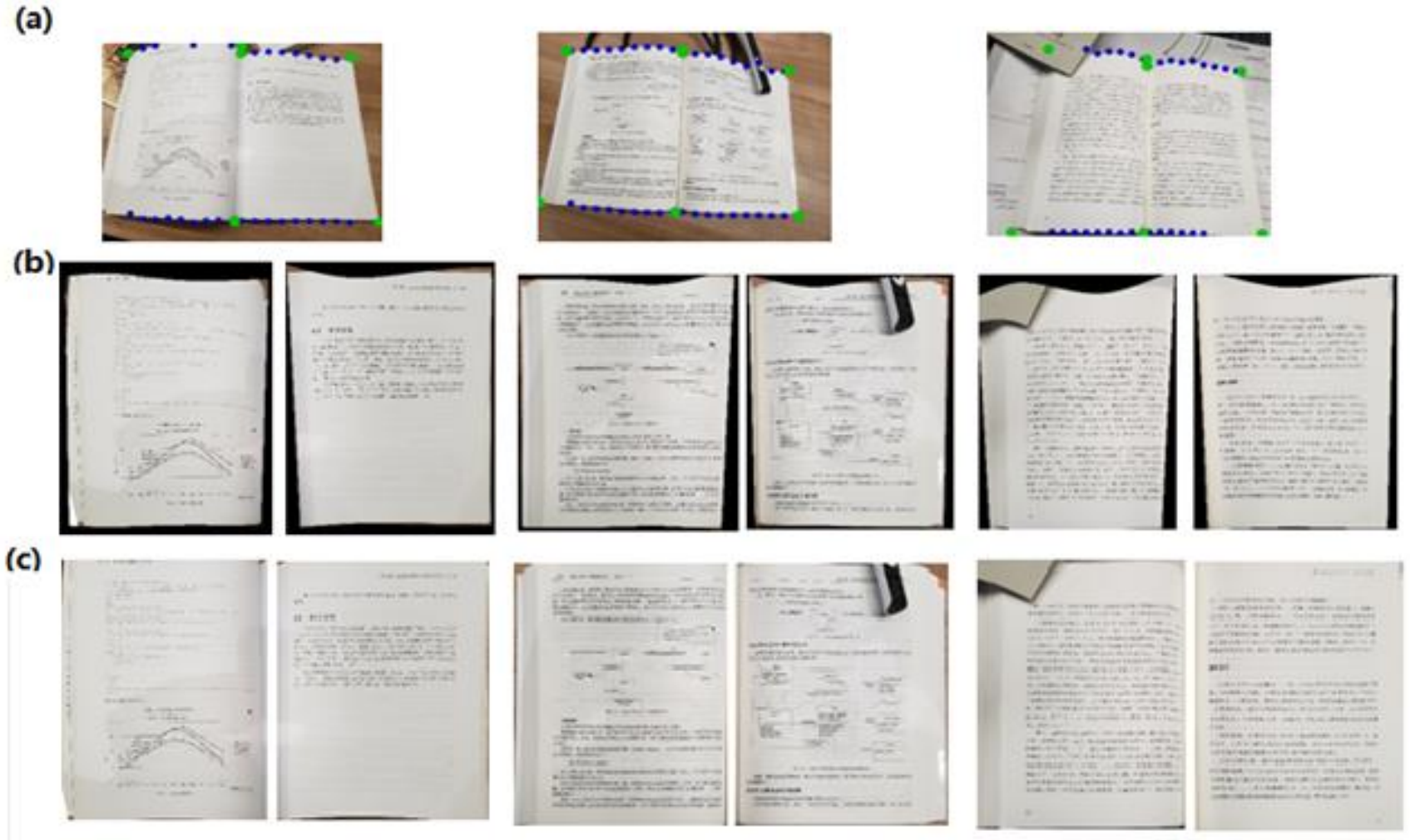



**Fig. 7. Page outline detection and dewarping results on our dataset. Upper panel**
**(a): detected page up-bottom boundary (blue dots) and page corner points on original image (green dots). Middle panel**
**(b): dewarping results obtained using Kil’ s method**
**(c): dewarping results obtained using ACTM.**

# One page cropping and dewarping

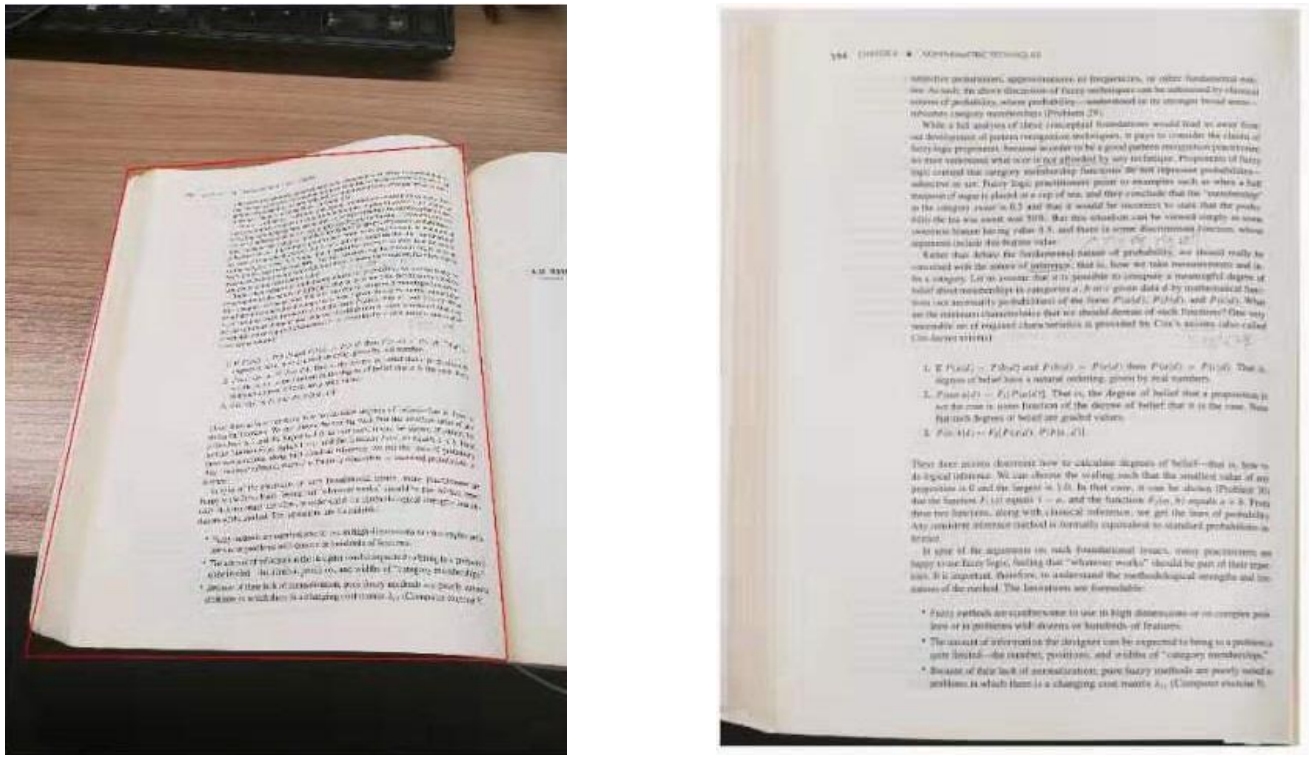
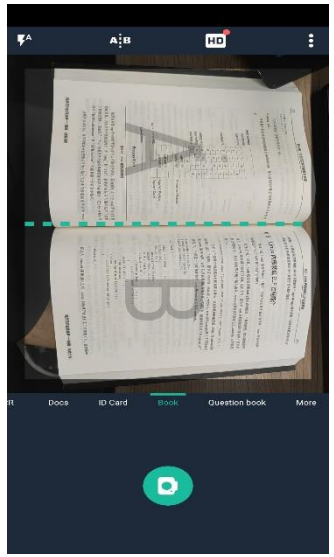


Fig. 8. One-page cropping & dewarping

# Conclusion

- **Method**
  - Fast page outline detection
  - Hybrid dewarping system
- **Advantage**
  - Low resource requirement
  - Robustly detect page outlines in complex background
  - Handle various layouts


| | Kil’s method [2] | ACTM |
|---|---|---|
| Time on Intel Core i7 (ms) | 1200 - 3000 | 200 |
| Time on Phone with Snapdragon 845 (ms) | / | 600 |

| | Original | Kil’s method | ACTM |
|---|---|---|---|
| OCR Accuracy | 80.7% | 93.4% | 93.2% |

[CamerScaner book model UI & Video]

*2 T. Kil, W. Seo, H. I. Koo, and N. I. Cho, "Robust document image dewarping method using text-lines and line segments," in 2017 14th IA Document Analysis and Recognition (ICDAR), 2017, vol. 1, pp. 865-870: IEEE*

# Thanks